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1.	Your Reference	PJS/P7051GB
2.	Patent application number *(The Patent Office will fill in this part)*	**9724775.3**
3.	Full name, address and postcode of the or of each applicant *(underline all surnames)*	DANISH DIAGNOSTIC DEVELOPMENT A/S Dr. Neergaardsvej 5F DK-2970 Horsholm DENMARK
	Patents ADP number *(if you know it)*	
	If the applicant is a corporate body, give the country/state of its incorporation	DENMARK 7331457001
4.	Title of the invention	LIGHT PULSE GENERATING APPARATUS AND THERAPEUTIC PHOTOTREATMENT
5.	Name of your agent *(if you have one)*	W.H.BECK, GREENER & CO.
	"Address for service" in the United Kingdom to which all correspondence should be sent *(including postcode)*	7 STONE BUILDINGS LINCOLN'S INN LONDON WC2A 3SZ
	Patents ADP number *(if you know it)*	323001

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6.	If you are declaring priority from one or more earlier patent applications, give the country and the date of filing of the or of each of these earlier applications and *(if you know it)* the or each application number			

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Continuation sheets of this form	
Description	17
Claim(s)	4
Abstract	
Drawing(s)	5 +5

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11. I/We request the grant of a patent on the basis of this application.

Signature Date 24.11.97

12. Name and daytime telephone number of person to contact in the United Kingdom. Mr P.J. Smart - (0171) 405 0921

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LIGHT PULSE GENERATING APPARATUS AND THERAPUETIC PHOTOTREATMENT

The present invention relates to apparatus for producing light pulses and to apparatus and methods using light for cosmetic or therapeutic photo-treatment.

Apparatus of this type may be used for therapeutic purposes including treatment for psoriasis, vascular traumas, telangiectasis, capillary hemangioma, cancerous cells, port-wine stains, and birthmarks and also for depilation.

WO 091/15264 describes a device for treatment of undesired skin disfigurements, which apparatus comprises a gas filled lamp and an optical filter. The lamp is powered by a capacitor charged to about 2,000 volts, which is sufficient for generating a pulse with a pulse duration between ½ and 1 ms.

EP 0 565 331 A2 describes a therapeutic treatment device which includes a gas filled flash lamp and a set of optical filters. The power circuit includes three different pulse forming networks, which may be triggered selectively or successively. Each pulse forming network includes a capacitance and an inductance and a relay contact to trigger the discharge. The three networks are designed for providing different pulse widths. The capacitors are charged to a voltage, typically in the range of from 500 volts to 5 kilovolts.

EP 0 736 308 A2 discloses a method and an apparatus for depilation, wherein an apparatus of a similar kind is used. According to this publication an energy fluence in the order of from 10 to 100 J/cm^2 is used for the purpose of killing hair follicles without burning the surrounding skin. The publication also suggests the use of an optically transparent water-based gel applied to the skin prior to

treatment and serving the purpose of providing a heat sink to prevent hyperthermia in the skin.

We have found several limitations and problems in devices and methods according to the prior art. Damage to the skin or burns occur very easily, making it difficult to find an energy level at which the pulses will be effective but will not harm the skin. Further the amount of heat absorbed in the optical filters may be excessive, frequently leading to destruction of the filters.

These problems are addressed by the various aspects of the invention set out below which may be used separately or in any combination.

According to the prior art, the power supply typically comprises a capacitor which is discharged to feed current through a series inductance and into the arc lamp. The prior art circuit creates a current pulse shaped approximately as one half period of a sine wave, rising from zero to a maximum and declining again to zero. We have found that the relatively gradual rise rate in the light power output at the commencement of each pulse is disadvantageous, as further described below.

In a first aspect, the present invention provides apparatus for producing a pulse of light, comprising:

a light source operable to provide an output of light in response to a power input, and

a power supply connected to the light source for providing said power input,

wherein said power supply is operable to provide power output pulses to drive said light source, to produce light output pulses during which light output pulses for at least 90% of the light output pulse duration the light power output

is from 75 to 125% of the time-weighted average light power output during the light output pulse.

This implies a much more rapid rate of rise in power at the start of the pulse and a higher rate of fall in power at the end of the pulse than is provided by a sine wave pulse power profile. This aspect of the invention aims at driving the light source on a current pulse which typically is shaped approximately as a square wave. Although the power requirement is indicated above in terms of the light power output, it will be understood that this is generally dependent on there being an electrical power input into the lamp (i.e. the output of the power supply) satisfying similar requirements in terms of electrical power.

Preferably, for at least 90% of the pulse duration the power output is from 90 to 110% of the time-weighted average power output during the pulse, most preferably from 95 to 105% of said value. Alternatively, it is preferred that for at least 95% of the light output pulse duration the light power output is from 75 to 125% of the time-weighted average light power output during the light output pulse, more preferably from 90 to 110% of said average value and most preferably from 95 to 105% of said value.

The time weighted average power output is given by the formula:

$$\frac{\sum p_n . t_n}{t}$$

where p_n is the power p at time t_n and t is the total pulse time $\sum t_n$.

Alternatively, the time from the commencement of the light pulse to the light pulse reaching full power is no more than 10 percent, more preferably no more than 1 percent of the duration of the pulse.

Preferably, means is provided for adjusting said time-weighted average light power output.

Arc lamps may be driven at different current levels, outputting different levels of optical radiation. However, this causes an associated shift in the spectrum. Thus the variation of the radiation in the short wave length range, e.g. below 700 nm tends to vary more than the variation in the longer wave length range. For instance on recording the optical output spectral density generated while driving an arc lamp at 100% and at 50% of maximum rated current, it was found that the optical output spectral density at 900 nm dropped to 67% of the preceding value, whereas the output at about 480 nm dropped to about 40% of the respective preceding value.

For depilation, optical radiation at wave lengths longer than 700 nm is favored for its ability to penetrate deeper into the skin. Thus, for this application the short wave length radiation is regarded as an unwanted output to be filtered away in optical filters. The result is an excessive power dissipation in the filters.

The changing spectrum of the arc lamp if driven on a varying current as provided by power supply units according to the prior art, also makes it very difficult to estimate the effective output after the filters. According to this aspect of the invention the lamp is driven on a substantially constant level of current, where the spectrum then is approximately unchanged and the energy delivered to the target proportionate to the duration of the square wave pulse or pulses.

The generation of this kind of drive signal requires a different electric circuit, which operates with a higher intrinsic power loss compared to the circuits of the prior

art. The invention therefore achieves the result referred to only at the cost of an increased power loss in the electric driving circuit. The shifting of the power loss to take place in the power supply unit rather in the optical filters is considered a major advantage, since power dissipated in the power supply unit may easily be kept away from the patient and from the sensitive optical components in the applicator.

The capability of the apparatus according to the invention of reducing the amplitude of the power output may be used to a substantial advantage. The inventors have found that the skin epidermis is capable of dissipating a greater amount of energy input than the tissue in the hair follicle. The difference, which may be in the order of factor of 20, is attributed to the greater thermal conductivity in the epidermal region. This difference more than offsets the disadvantage of the more limited penetration to the hair follicles.

Hence, for a given irradiation input, the hair follicle is heated to a higher temperature than the epidermis. This means that it is possible to establish a level where the hair follicles may be killed without harming the epidermis. The exact level may vary depending on skin pigmentation and has to be established for the particular patient. The procedure of establishing a proper level is considered to lie within the capabilities of those skilled in the art. The apparatus according to the invention is capable of outputting a treatment signal at a power level which is accurately controlled, in order to provide just the desired irradiation input.

The apparatus preferably further comprises a housing for said light source, an aperture defined by said housing and a reflector in said housing positioned to reflect a beam of light through said aperture.

The apparatus preferably further comprising an optical filter in the path of said light beam, said optical filter being adapted to pass only selected wavelengths of said light.

According to a second aspect of the invention there is provided apparatus for generating a beam of light for selective photo-treatment comprising:

a light source operable to provide an output of incoherent photo-radiation for treatment,

a power supply connected to the light source,

a housing including a reflector and an aperture,

an optical filter adapted for passing only a selected band of optical wavelengths,

wherein the power supply is adapted to feed the light source for a predetermined interval of time and in such a way as to keep over this predetermined interval of time the amplitude of the photo-radiation output to stay below a preselected maximum value and above a preselected minimum value.

Preferably, the preselected minimum value is at least 50% of the preselected maximum value.

Preferably, the power supply is provided with means for adjusting the level of the preselected maximum value according to the treatment required.

According to either aspect of the invention the light source preferably comprises a gas-filled arc lamp. Preferably, said gas-filed arc lamp is a xenon or krypton lamp.

Preferably, a single light pulse is applied to each treatment location.

It will be appreciated that, at a particular light power output, to provide a sufficient energy input into the target, e.g. a hair follicle or blood vessel within the skin, one may need to apply the light energy for a longer period than can be attained or attained conveniently by a single pulse from such a lamp. Accordingly, the apparatus may provide a series of pulses to the treatment location, e.g. from 1 to 10, more typically from 1 to 6, e.g. 1 to 4 pulses, spaced by from 3 to 10 sec.

The duration of each such pulse may be from up to 100 msec, e.g. from 2 to 100 msec, more preferably from 30 to 70 msec. Preferably, the pulses are relatively long and relatively low in power rather than delivering the same amount of energy to the treatment site by being higher in power and shorter. In the case of depilation, this allows advantage to be taken of the differing thermal relaxation times of the skin and the hair follicle, so that heat is permitted to be lost from the skin, preventing burning, while heat accumulates in the hair follicle. Thus, the optimum pulse duration can be determined according to a relaxation time based algorithm.

However, the use of long pulses (e.g. 50 msec.) may shorten the life of gas discharge lamps and accordingly, we prefer to divide each long pulse into a series of closely spaced sub-pulses, each having the power profile specified above. The duration of each such sub-pulse may be from 2 to 25 msec and the spacing between such sub-pulses is preferably from up to 3 msec, e.g. 0.2 to 1.5 msec. Preferably, in such a case both each such sub-pulse and the longer pulse to which they contribute satisfy the power profile requirements set out above, although it is sufficient that either does.

If apparatus for photo-treatment is to be used for treating a variety of conditions, it will normally be necessary that the light output be filtered differently according to the condition treated. There will normally therefore be provided a plurality of filters having differing

filter characteristics and it will often be a matter involving the safe operation of the apparatus that the filter or the appropriate one be in place before treatment commences.

Accordingly there is provided according to a further aspect of the invention apparatus for photo-treatment comprising a light source, means for receiving a filter adapted to pass only selected wavelengths of light so as to dispose said filter in a light path from said light source, sensor means for detecting the presence and/or nature of a said filter in said filter receiving means, and interlock means for preventing operation of said light source to carry out photo-treatment except when a said filter or a said filter appropriate to an intended photo-treatment is present in said receiving means and/or for providing an alarm signal if a said filter or appropriate filter is not present in said receiving means.

This may be achieved by placing an electrically resistive circuit path, e.g. a resistive track, on the filter and providing means in the filter receiving means for measuring the electrical resistance of the track. Different filters will be provided with different resistances.

Alternatively, this may be achieved by a mechanical sensor detecting the presence of a filter in the filter receiving means, e.g. a sprung plunger which is depressed by the introduction of a filter and which actuates an electrical switch to make or break a circuit to allow operation of the apparatus. Different filters may be mechanically sensed by respective switches if they differ physically in thickness or shape. Preferably however there is at least one light source and at least one light sensor operatively arranged to observe the filtering activity of the filter on transmitted or reflected light and suitable electronic control means to determine the presence and optionally the nature of the filter from the light detected by said sensor or sensors.

The filters employed in photo-treatment apparatus of this type in the past have been of the interference type which comprise a non-filtering substrate bearing an extremely thin coating, typically of several layers of the order of the wavelength of light in thickness. We have found that at the high light intensities needed in photo-treatment apparatus, such filters are prone to damage. Any particle of dust on the filter surface can adsorb the light energy and become heated to a temperature which causes a pin-hole to form in the filter coating, allowing unfiltered light through.

Accordingly, there is provided according to a further aspect of the invention apparatus for photo-treatment comprising a light source, a filter adapted to pass only selected wavelengths of light disposed in a light path from said light source, said light source being adapted to produce a light flux of at least 250 J/cm^2/sec, wherein said filter is a non-interference absorption filter.

Such a filter is preferably of heat resistant glass or other heat resistant transparent material having a pigment distributed throughout its thickness. Additionally, a coated reflection filter may be formed on the surface of such a filter nearer the light source to reflect energy away so as to reduce adsorption in the filter and heating of the filter.

It is known to cool the lamp in this type of apparatus by circulating a cooling liquid, normally water, through channels in the material of the lamp housing. We have appreciated that this is a less than ideal approach. Accordingly, there is provided according to a further aspect of the invention apparatus for photo-treatment comprising a light source and means for circulating a cooling liquid in contact with said light source.

Preferably, such apparatus further comprises a filter adapted to pass only selected wavelengths of light

disposed in a light path from said light source and also in contact with said cooling liquid.

The cooling liquid is preferably water. Not only does water have a direct cooling function in the apparatus itself, we have appreciated that it acts as an ideal infra red filter, being adapted to filter out just those wavelengths which would cause heating of the skin of the patient, in which water is a principal infra red absorber. More generally therefore, the invention includes the use of water in the light path of photo-treatment apparatus as an infra red filter. Whilst this is preferably achieved by circulating the water over the lamp as a coolant as described above, water instead may be contained in a vessel in the light path to act purely as a filter. By the term 'water' in this context we include not only pure water but aqueous liquids generally, and in the case of the filter described above we include non-flowable transparent aqueous materials such as gels also.

As the coolant liquid may expand due to heating, the apparatus preferably includes a pressure relief device.

The power supply for driving the light source preferably comprises a capacitor, a charging circuit adapted for charging the capacitor to a preselected voltage, a resistor in series between said capacitor and said light source and a discharge switch operable to change from a non-conductive state to a conductive state to cause said capacitor to discharge said light source and back to said non-conductive state again.

Preferably, when the light source is an arc lamp the power supply comprises a simmer generator adapted for feeding the arc lamp with power at a level which is sufficient to keep the arc in the conductive state.

According to a further aspect of the invention there is provided apparatus for applying photo-radiation on to a tissue, comprising:

a housing including a reflector and an aperture,

a gas-filled arc-lamp,

an optical filter adapted for passing only a selected band of optical wavelengths,

a light guide for transmitting light from the aperture to the tissue, and

means adapted for measuring the reflection of light from the tissue.

The reflection measuring means may include a respective light source providing light to be reflected by the tissue. The measurement of the reflection of particular wavelengths or wavelength bands of light may be used to form a judgement regarding the skin coloration which in turn may be used in calculating the appropriate photo-treatment. The main light source may be used for this purpose.

The invention further provides a method of treating live tissue for cosmetic purposes. Cosmetic treatments envisaged include hair depilation, tattoo removal, wrinkle smoothing, skin rejuvenation, removal of disfiguring skin ailments and birthmarks.

The invention further provides a method for treating live tissue for therapeutic purposes. Therapeutic purposes envisaged comprise treatment for psoriasis, vascular traumas, telangiectasis, capillary hemangioma, cancerous cells, removal of birthmarks, etc. Such treatment methods include not only those in which the light acts directly on the tissues but also methods of photo-dynamic therapy in which the light acts on a substance applied to or administered to the body and activates the substance, e.g. cleaves a prodrug to release the active material at a treatment site.

Further objects, features and advantages of the invention will appear from the appended detailed description given with reference to the enclosed drawings, wherein

Figure 1 illustrates a circuit diagram of a power supply with a lamp according to the invention;

Figure 2 illustrates a transverse cross-section through a photo-treatment apparatus according to the invention including for use with the power supply arrangement of Figure 1;

Figure 3 is a longitudinal cross-section through the apparatus of Figure 2;

Figure 4 is a time chart of the current fed through the lamp of Figure 1 during a pulse;

Figure 5 is a chart of the luminous spectral density of the output of a Xenon lamp driven according to the prior art and the circuit of Figure 1; and

Figure 6 shows an arrangement for focussing the light output to a distance below the skin in apparatus as shown in Figures 1 to 3.

All drawings are schematic, illustrating only the principal features of the apparatus, including those essential to enable those skilled in the art to practise the invention whereas other features are omitted from the drawings for the sake of clarity. Throughout the drawings the same references are used to designate identical or similar features.

Reference is first made to Figure 1 illustrating the driving circuit and the lamp.

The circuit in Figure 1 comprises a control unit in the form of a personal computer (PC) used to control the

system. The PC is connected to a power supply which is adapted to charge through the diode D1 the capacitor C. In a preferred embodiment the power supply is adapted to charge the capacitor to a voltage set from the PC to a level in the range from 100 - 1000 volts. In a preferred embodiment the capacitance of the capacitor C is 10 to 100 mF.

The capacitor C is connected through diode D2 and resistor R to the flash lamp 3. The circuit is completed by a solid state switch IGBT, which is in the preferred embodiment implemented in the form of an isolated gated bi-polar transistor. The IGBT is controlled from the PC by the line designated FLASH. The IGBT is capable of changing from non-conductive to conductive state, of carrying currents in the range of 500 A and of changing from conductive to non-conductive state again, breaking this current.

On the right hand side of Figure 1 a simmer power supply is illustrated. This power supply is capable of feeding the flash lamp through the diode D3 with a simmer current in the order of 100 mA. In order to ignite the flash lamp the simmer power supply outputs a short pulse at a voltage of about 10 - 20 kilovolts on the electrode designated TRIGGER. The simmer current maintains a narrow arc inside the gas-filled lamp to keep this lamp in the conductive state.

Figure 1 also illustrates photo-detector 9 adjacent the flash lamp and connected to convey data about the illumination level to the control unit PC.

Reference is now made to Figure 2 illustrating a vertical transverse section in the applicator according to the invention. The applicator comprises housing 1, lamp 3, reflector 2 surrounding the lamp, IR filter 5, removable filter 6, light guide 7 and pressure relief device 8. The reflector 2 is shaped to direct the light output of the lamp downwards as illustrated in the figure. The edge of the reflector 2 constitutes the aperture 10.

The reflector together with the IR filter forms a generally closed chamber 4 which is filled with water.

The pressure relief device comprises a bulb-like expanded chamber filled with air and in fluid communication with the chamber 4. This air-filled chamber acts like a spring capable of smoothing out any pressure shocks in the water chamber that may be caused by the sudden discharges of the lamp.

The IR filter 5 is adapted to absorb a part of the light in the infrared range. IR light is also absorbed by the water.

More preferably, one may rely more on the water to adsorb infra red and one may make the filter a long wavelength pass filter adsorbing shorter wave lengths, e.g. UV and near UV shorter than 510 nm.

One may thus pass light of wavelength from 510 to 600 nm, e.g. 510 to 590 nm, according to the therapeutic requirement.

The long wave pass filter occupies the same location shown in IR filter 5.

The removable filter 6 is of coloured heat resistant glass (optionally combined with coated reflection filters and coloured filters) and may be substituted with other filters of similar type in order that the operator may chose from a selection of filters with different optical band widths.

Reference is now made to Figure 3, which illustrates a vertical longitudinal section through the applicator from Figure 2. Figure 3 illustrates generally the same parts as those appearing in Figure 2 plus the photo-detector 9 in the upper portion and the water conduits 11 carrying water for

cooling the interior of the applicator. The photo-detector detects light reflected from the skin, preferably at the low level of irradiation prevailing during intervals of simmer operation, enabling the system to estimate the reflectivity or the pigmentation of the skin. The photo-detector further enables the system to verify the proper operation of the flashing circuitry.

Figure 3 symbolically illustrates an area of treatment comprising epidermis 12, dermis 13 and a hair 14 in a hair follicle 15.

Reference is now made to Figure 4 illustrating a time chart of the current fed through the Xenon lamp during a pulse of treatments. Figure 4 illustrates a pulse of a duration of 100 ms. The pulse rises practically immediately to a level of 338 A and decays exponentially to about 276 A after 100 ms.

Thus, the circuit of the preferred embodiment approximates the desired square wave by a sloping exponential decay with a time constant depending on the capacitance of the capacitor, the series resistor R, and the current driven through the Xenon lamp. Generally, satisfactory results are achieved if the current decays from 100% to somewhere above 50% of the initial value.

Reference is now made to Figure 5 illustrating a chart of power spectral density of the radiation output by the Xenon lamp. Figure 5 comprises two graphs, one drawn for a Xenon lamp at a current density of 2400 A per cm^2 and illustrating the optical output from a wave length about 420 nm up to about 1100 nm, the other curve showing the output of a current at half of this level. The curve illustrates the fact that the spectral output drops in a frequency dependent manner on the reduction of the drive current. For instance at 900 nm the output drops to approximately 65% while the output

at 480 nm drops to about 40%, both taken relative to the respective preceding values.

In order to use the system for treatment, an operator would place the applicator adjacent a selected treatment area and set the control unit to carry out an initialization routine. As part of this routine, the operator would enter data into the control unit concerning the patient and the type of treatment desired. In one preferred embodiment, the control unit is programmed to ignite the flash lamp and burn it on the simmer power supply in order provide a low level of irradiation, by which the control unit through the utilization of the photo-detector will establish the reflectivity value of the treatment area. These data enable the control unit to suggest an appropriate irradiation scheme, which may comprise pulse level and pulse duration.

Once the operator has accepted the treatment scheme, he will only need to move the applicator to the respective treatment areas and activate a flash trigger, while the control unit will verify that contact is established, and that the reflectivity has the presumed value, and will then output the appropriate treatment signal.

As shown in Figure 6, the apparatus may include means for focussing the light output to concentrate it at a selected level below the skin. This reduces the energy density at the skin surface for a given energy density at the treatment site. The focussing depth may be made adjustable by a focussing mechanism or by the provision of separate lenses that may be swapped or supplemented with one another.

Although various components, systems and methods have been explained in particular settings above, this is not to exclude that such components, systems or methods might be applied in other settings or applied differently. The particular examples mentioned have only been mentioned with the purpose of facilitating the understanding of the invention

and not with the purpose of limiting the scope whereof which is defined exclusively by the appended patent claims.

CLAIMS

1. Apparatus for producing a pulse of light, comprising: a light source operable to provide an output of light in response to a power input, and

a power supply connected to the light source for providing said power input, wherein said power supply is operable to provide power output pulses to drive said light source to produce light output pulses, during which light output pulses for at least 90% of the light output pulse duration the light power output is from 75 to 125% of the time-weighted average light power output during the light output pulse.

2. Apparatus as claimed in Claim 1, wherein for at least 90% of the pulse duration the light power output is from 90 to 110% of the time-weighted average light power output during the pulse.

3. Apparatus as claimed in Claim 1 or Claim 2, wherein for at least 95% of the light output pulse duration the light power output is from 75 to 125% of the time-weighted average light power output during the light output pulse.

4. Apparatus as claimed in any preceding claim, wherein means is provided for adjusting said time-weighted average light power output.

5. Apparatus as claimed in any preceding claim, further comprising a housing for said light source, an aperture defined by said housing and a reflector in said housing positioned to reflect a beam of light through said aperture.

6. Apparatus as claimed in any preceding claim, further comprising an optical filter in the path of said light beam, said optical filter being adapted to pass only selected wavelengths of said light.

7. An apparatus for generating a beam of light for selective photo-treatment comprising:
   - a light source operable to provide an output of incoherent photo-radiation for treatment,
   - a power supply connected to the light source,
   - a housing including a reflector and an aperture,
   - an optical filter adapted for passing only a selected band of optical wavelengths,
   - wherein the power supply is adapted to feed the light source for a predetermined interval of time and in such a way as to keep over this predetermined interval of time the amplitude of the photo-radiation output to stay below a preselected maximum value and above a preselected minimum value.

8. Apparatus as claimed in Claim 7, wherein the preselected minimum value is at least 50% of the preselected maximum value.

9. Apparatus according to Claim 7 or Claim 8, wherein the power supply is provided with means for adjusting the level of the preselected maximum value according to the treatment required.

10. Apparatus for photo-treatment comprising a light source, means for receiving a filter adapted to pass only selected wavelengths of light so as to dispose said filter in a light path from said light source, sensor means for detecting the presence and nature of a said filter in said filter receiving means, and interlock means for preventing operation of said light source to carry out photo-treatment except when a said

filter appropriate to an intended photo-treatment is present in said receiving means and/or for providing an alarm signal if a said appropriate filter is not present in said receiving means.

11. Apparatus for photo-treatment comprising a light source, a filter adapted to pass only selected wavelengths of light disposed in a light path from said light source, said light source being adapted to produce a light flux of at least 250 $J/cm^2/sec$, wherein said filter is a non-interference absorption filter.

12. Apparatus for photo-treatment comprising a light source and means for circulating a cooling liquid in contact with said light source.

13. Apparatus as clamed in Claim 12, further comprising a filter adapted to pass only selected wavelengths of light disposed in a light path from said light source and also in contact with said cooling liquid.

14. Apparatus as claimed in any one of the preceding claims, wherein the light source comprises a gas-filled arc lamp.

15. Apparatus as claimed in Claim 14, wherein said gas-filed arc lamps is a xenon or krypton lamp.

16. Apparatus as claimed in any one of the preceding claims, wherein the power supply comprises a capacitor, a charging circuit adapted for charging the capacitor to a preselected voltage, a resistor in series between said capacitor and said light source and a discharge switch operable to change from a non-conductive state to a conductive state to cause said capacitor to discharge said light source and back to said non-conductive state again.

17. Apparatus according to Claim 16, wherein the light source is an arc lamp and the power supply comprises a simmer generator adapted for feeding the arc lamp with power at a level which is sufficient to keep the arc in the conductive state.

18. Apparatus for applying photo-radiation to a tissue, comprising:

- a housing including a reflector and an aperture,
- a gas-filled arc-lamp,
- an optical filter adapted for passing only a selected band of optical wavelengths,
- a light guide for transmitting light from the aperture to the tissue, and
- a photo-detector adapted for detecting light reflected from the tissue.

19. Apparatus as claimed in Claim 18, comprising means for cooling by water.

20. Apparatus as claimed in Claim 19, comprising a pressure relief device.

21. Apparatus as claimed in any preceding claim wherein there is means for focussing the light output to concentrate the same at a selected depth below the surface of the treatment location.

22. A method of treating live tissue for cosmetic purposes, wherein an apparatus as defined in any one of the preceding claims is used.

23. A method of treating live tissue for therapeutic purposes, wherein an apparatus as defined in any one of the preceding claims is used.

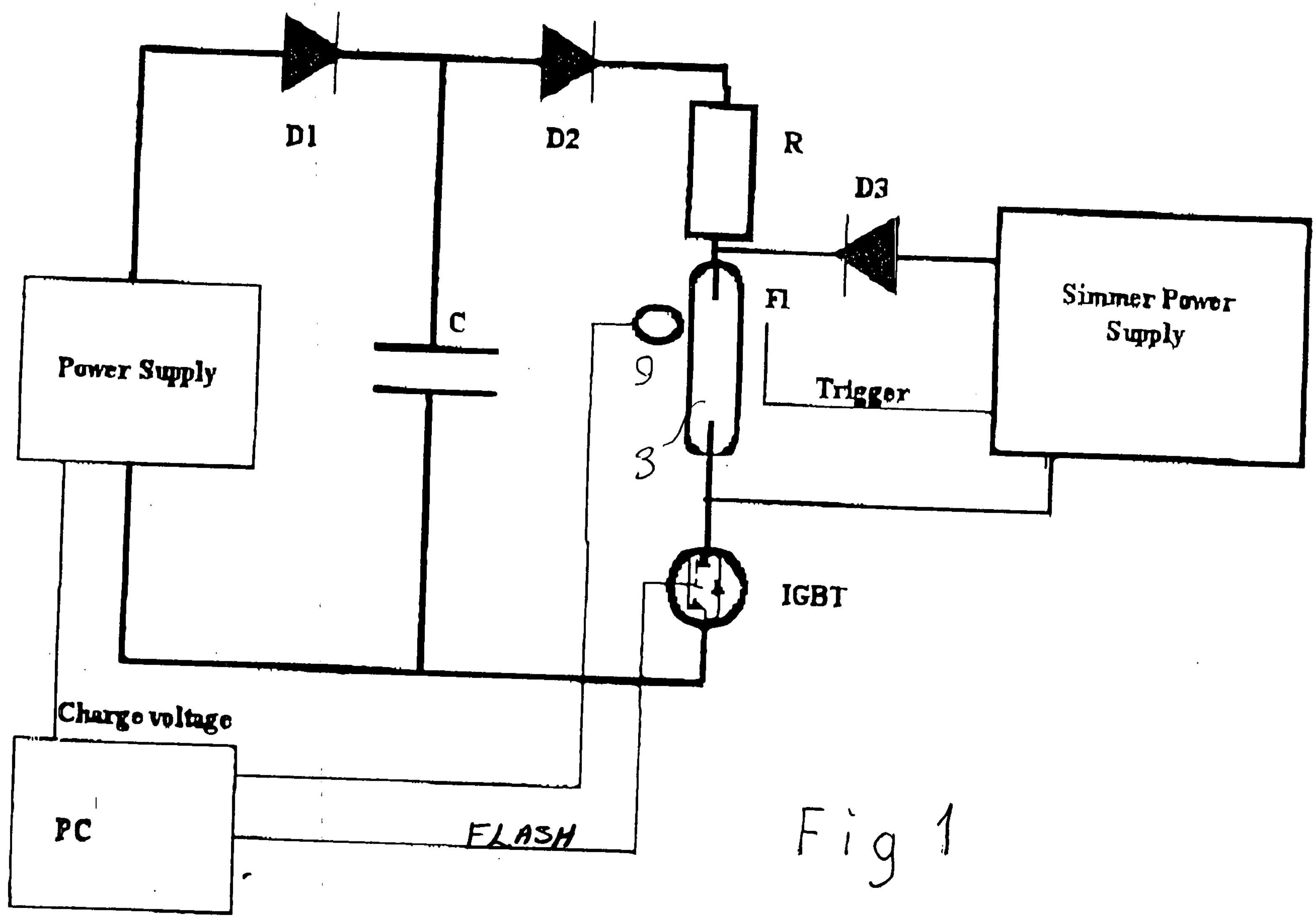
D1
D2
R
D3
C
Fl
Simmer Power Supply
Power Supply
9
3
Trigger
IGBT
Charge voltage
PC
FLASH

Fig 1

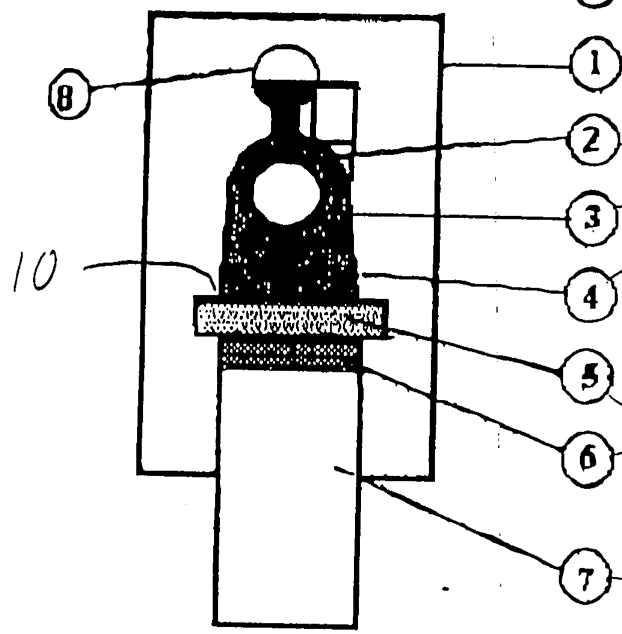

Fig 2

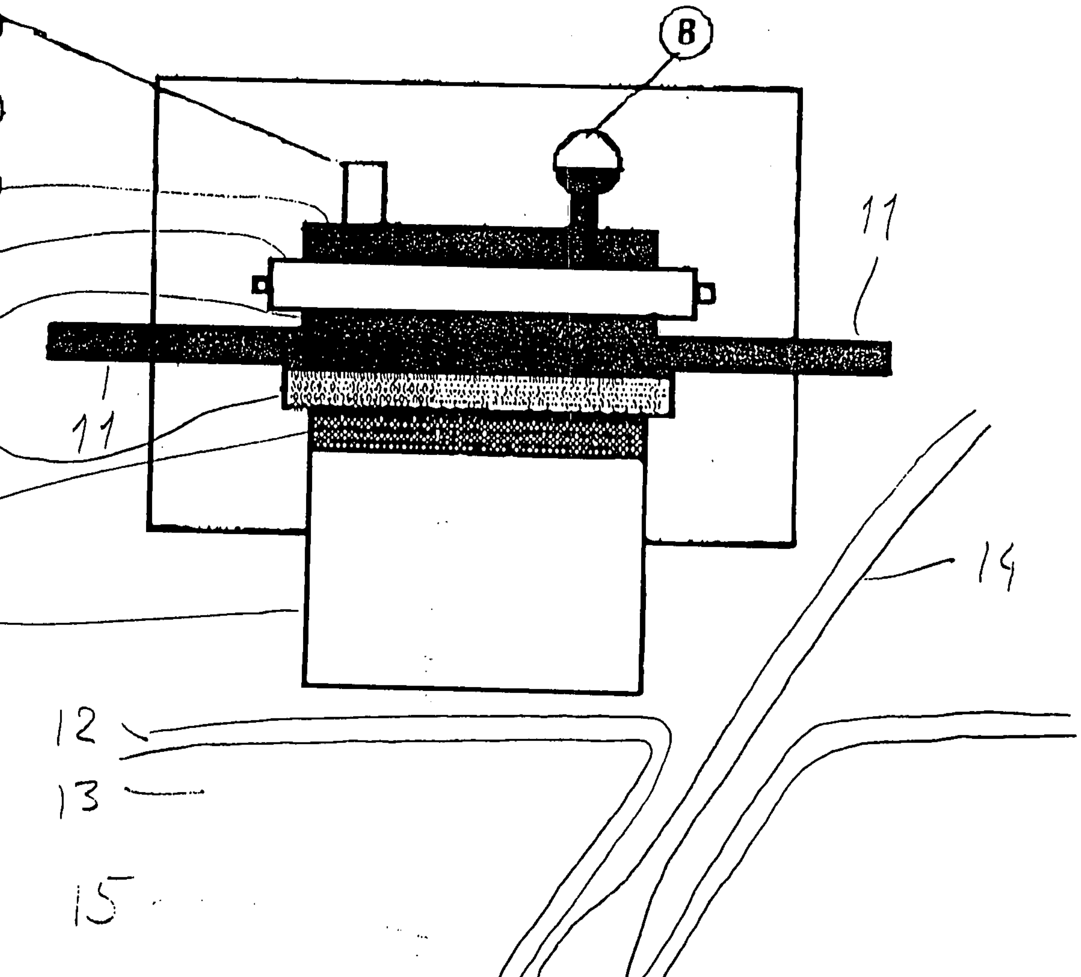

Fig 3

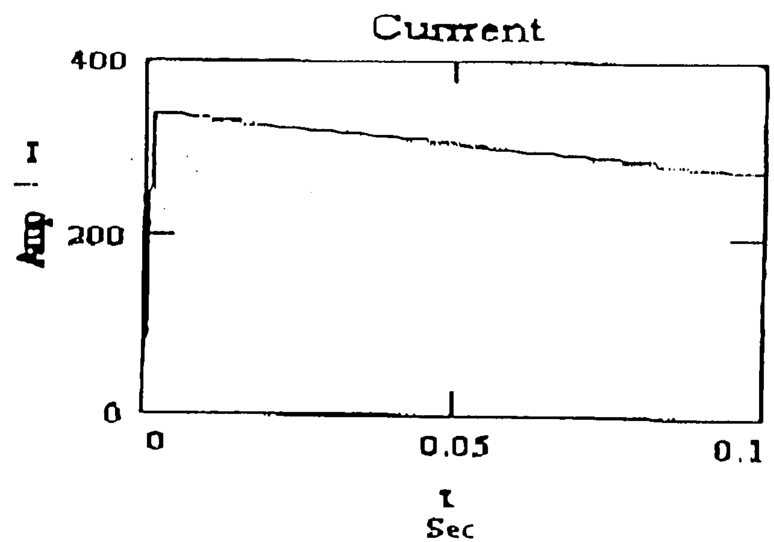

Fig 4

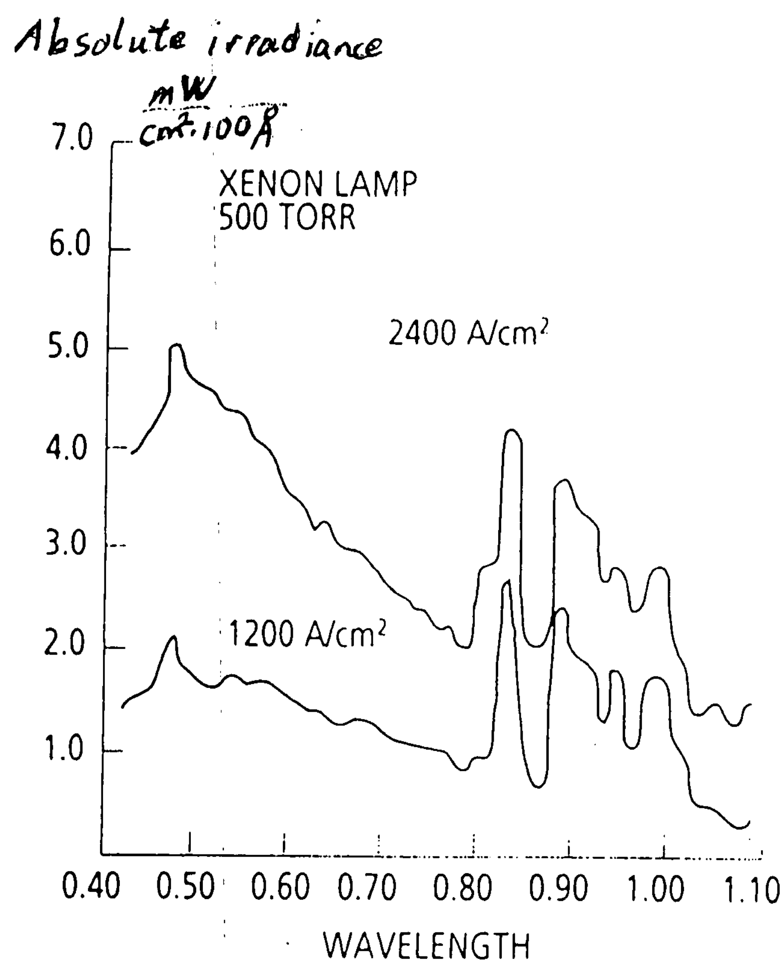
Absolute irradiance
mW / cm².100Å
7.0
6.0
5.0
4.0
3.0
2.0
1.0
XENON LAMP
500 TORR
2400 A/cm²
1200 A/cm²
0.40 0.50 0.60 0.70 0.80 0.90 1.00 1.10
WAVELENGTH

Fig 5

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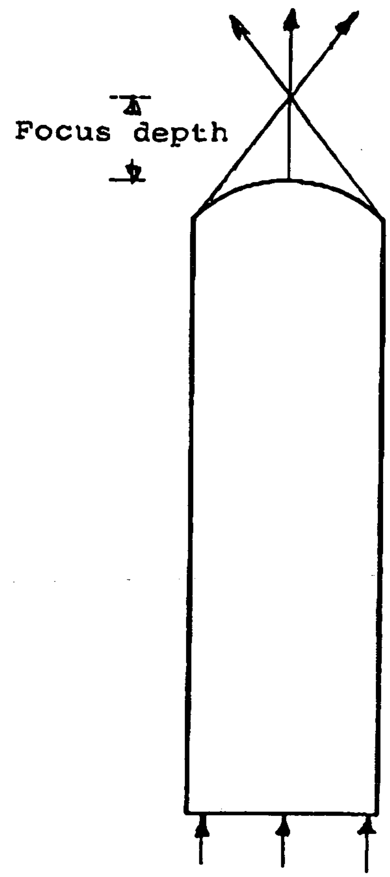

Fig 6.

Application No: 09, 097, 383
Pillsbury Madison & Sutro
Inventor: Christiansen
Filed: 6/16/98
Client & Ref. #: Beck Greener P705105
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